

Design and Testing of a small Inductive Pulsed Plasma Thruster

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I. Abstract

THE design and testing of a small inductive pulsed plasma thruster (IPPT), shown in Fig. 1 with all the major sub-systems required for a thruster of this kind are described. Thrust measurements and imaging of the device operated in rep-rated mode are presented to quantify the performance envelope of the device.

The small IPPT described in this paper was designed to serve as a test-bed for the pulsed gas-valves and solid-state switches required for a IPPTs. A modular design approach was used to permit future modifications and upgrades. The thruster consists of the following sub-systems: a) a multi-turn, spiral-wound acceleration coil (27 cm o.d., 10 cm i.d.) driven by a 10 μ F capacitor and switched with a high-voltage thyristor, b) a fast pulsed gas-valve, and c.) a glow-discharge pre-ionizer (PI) circuit. The acceleration-coil circuit may be operated at voltages up to 4 kV (the thyristor limit is 4.5 kV). The device may be operated at rep-rates up to 30 Hz with the present gas-valve. Thrust measurements and imaging of the device operated in rep-rated mode will be presented.

The pre-ionizer consists of a 0.3 μ F capacitor charged to 4 kV and connected to two annular stainless-steel electrodes bounding the area of the coil-face. The 4 kV potential is held across them and when the gas is puffed in over the coil, the PI circuit is completed, and a plasma is formed. Even at the less than optimal base-pressure in the chamber ($\sim 5 \times 10^{-4}$ torr), the PI held-off the applied voltage, and only discharged upon command.

For a capacitor charge of 2 kV the peak coil current is 4.1 kA, and during this pulse a very bright discharge (much brighter than from the PI alone) was observed (see Fig. 2). Interestingly, for discharges at this charge voltage the PI was not required as the current rise rate, dI/dt , of the coil itself was sufficient to ionize the gas.

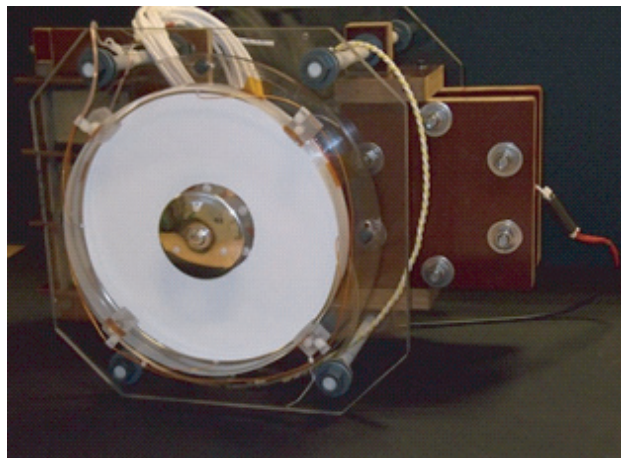


Figure 1. The assembled thruster shown end-on prior to installation in the vacuum chamber.

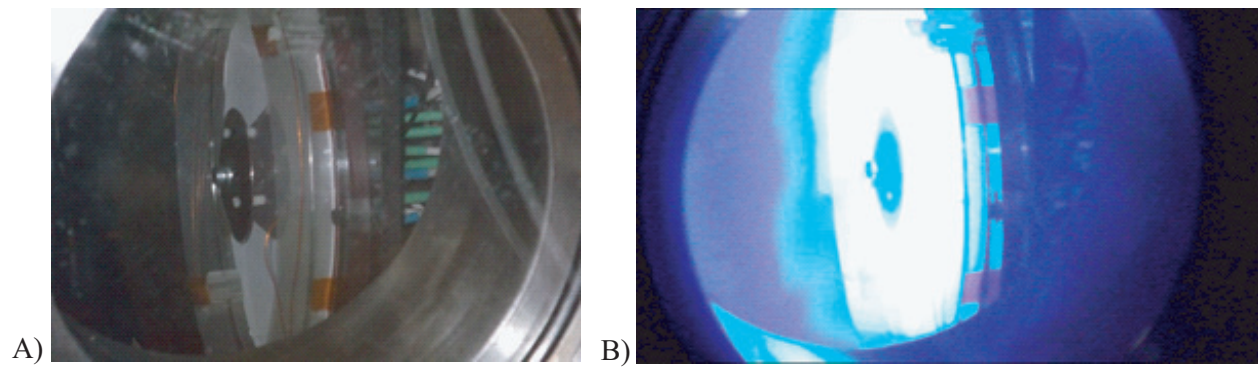


Figure 2. a) The thruster mounted in the vacuum chamber and b) a time-integrated image of the plasma produced during a single pulse at a capacitor charge of 2 kV.